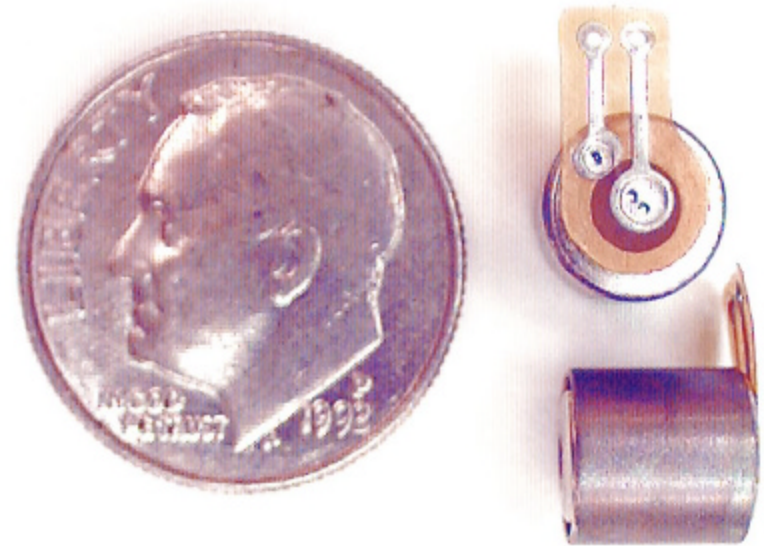


46th Annual Fuze Conference San Antonio, TX



Mark Peabody
Thomas Griffin
Ken Outt

Eagle-Picher Technologies, LLC Joplin MO
INDIV NSWC, Indian Head, MD
Eagle-Picher Technologies, LLC Joplin MO

M80 PIP Reserve Battery Development Team

- **Members**

- Eagle-Picher, Inc. - Reserve Battery Developer/Manufacturer
- ARL/Adelphi - Battery Technical Consultants
- IHDIV NSWC - Battery Design, Test and Evaluation
- NSWCDD/ARDEC, Adelphi - M80 PIP Packaging Design
- KDI Precision Products, Inc. - M234 SD Fuze/M80 PIP Producibility Consultant

- **Test Facilities**

- NSWCDD/ARDEC, Picatinny - Air and Rail Guns
- Eagle-Picher, Inc - Shock Tower, Vibration Tables, Environmental Lab
- IHDIV NSWC - Guided Drop Tower , VHG Machine

Reserve Batteries

- The primary source of power for military deployable weapon systems is the **reserve battery**.
- A **reserve battery** has the active chemical components separated until the battery is activated.
- Major attributes of reserve batteries:
 - Long term storage with no degradation of battery potential
 - (10 - 20 year shelf life typical)
 - No maintenance
 - High power capability at activation
 - Storage safety (battery is benign until activation)

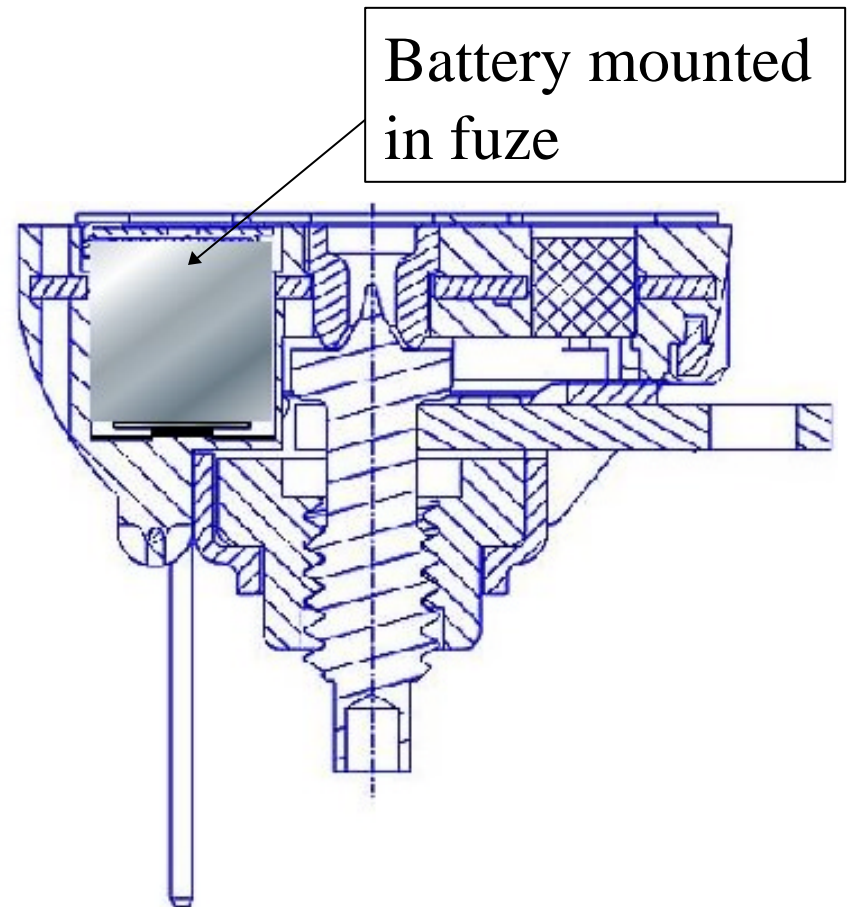
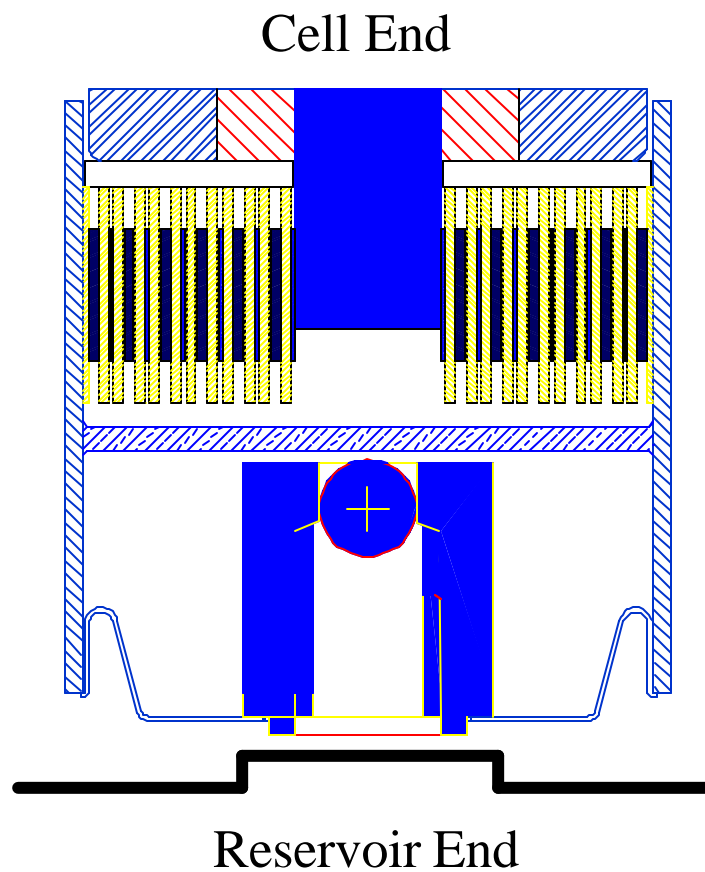
- **Electron Beam Vapor Deposited Lithium Anode**
 - Thickness < .0005"
 - Allows for high electrode surface area
- **Thin Catalyzed / Carbon Electrode**
 - Increases voltage / reduces impedance
 - Increases energy utilization
 - Thickness < 0.004"
- **Acid Oxyhalide Liquid Catholyte**
 - Produces heat for low temperature activation
 - Increases OCV / lowers impedance
- **Composite Glass/Microporous Electrode Separation**
 - Total thickness < 0.004"
 - Increased tensile strength > ten times over STD separator

Battery Requirements Summary

- Voltage **3 to 4.1Volts**
- Dimensions **0.255" dia. X 0.275" long**
- Electrical Load (Prox) **22 mA for 18 seconds**
- Operational Timeline **> 10 minutes**
- Operating Temperature **+20° F to +145° F**
- Operating Dynamics
 - Activation at gun firing 8500 g's to 12,000 g's
 - Expulsion 35Kg's for 50 ms in both directions
- Non-Operating
 - Vibration and shock (transportation and Handling)
 - **Drop 5 Foot with out activation**
 - **Storage 20 years**

Design Overview

Battery Cross-Section

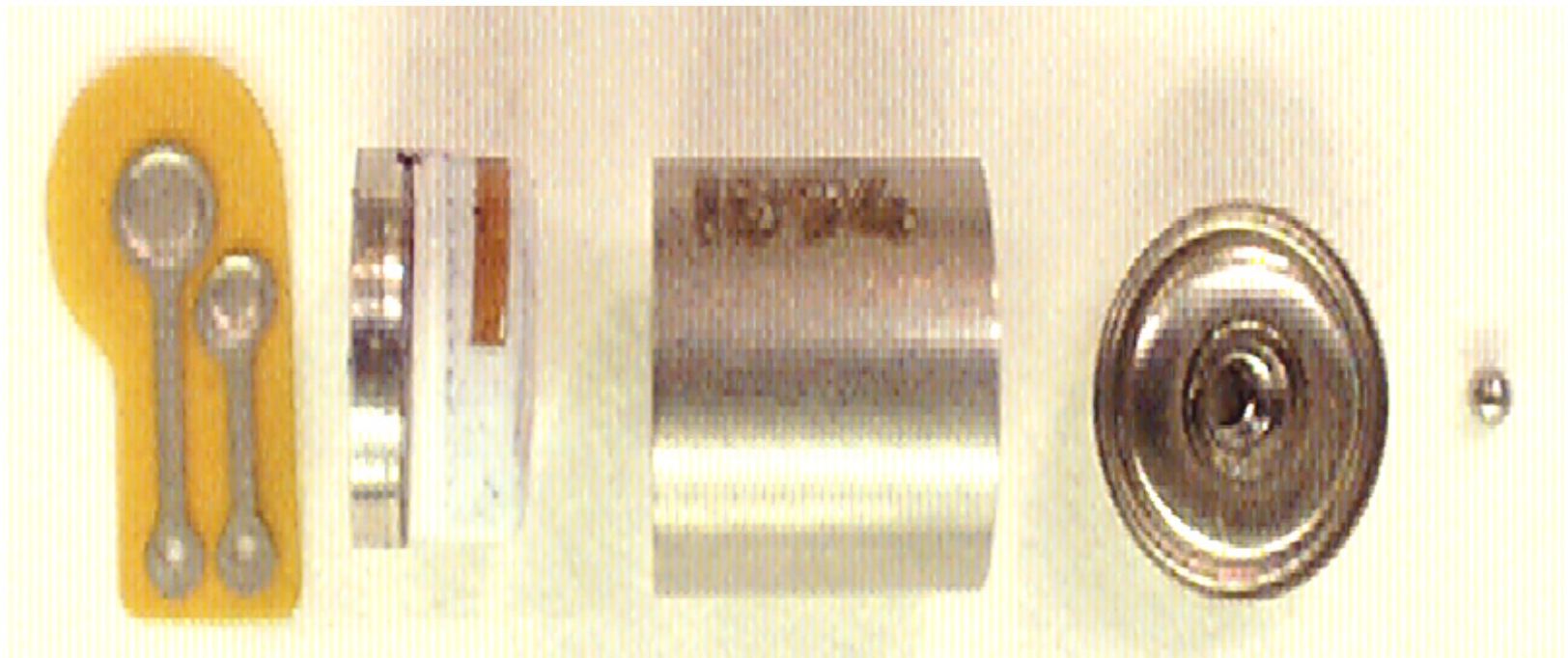


Direction of acceleration

Battery Assembly

Cell
Assembly

Reservoir Cover
Assembly



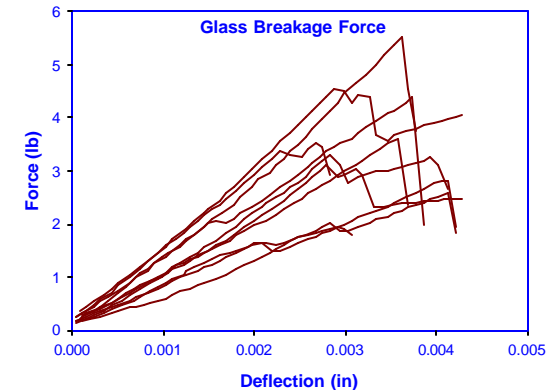
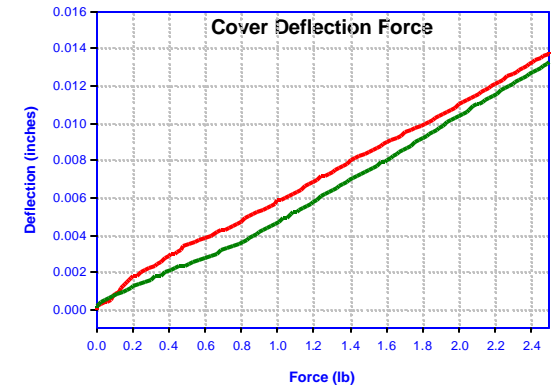
Flex-Circuit

Glassed Reservoir
Battery
Tube

Ball
Seal

Battery Activation Force

- Battery Activation Methods
 - Gun Setback / M80 Requirement
 - Static force on reservoir end
 - Electrical igniter shock
- Static Force Required For Activation
 - Total Maximum Force 7.4 pounds
 - Cover deflection 1.4 to 1.9 pounds
 - Glass Breakage 2.5 to 5.5 pounds
- Dynamic Force Available From Gun Setback
 - 8500 g's X effective battery weight
(0.605 grams) = 11.3 pounds
- Static Activation Margin 34%



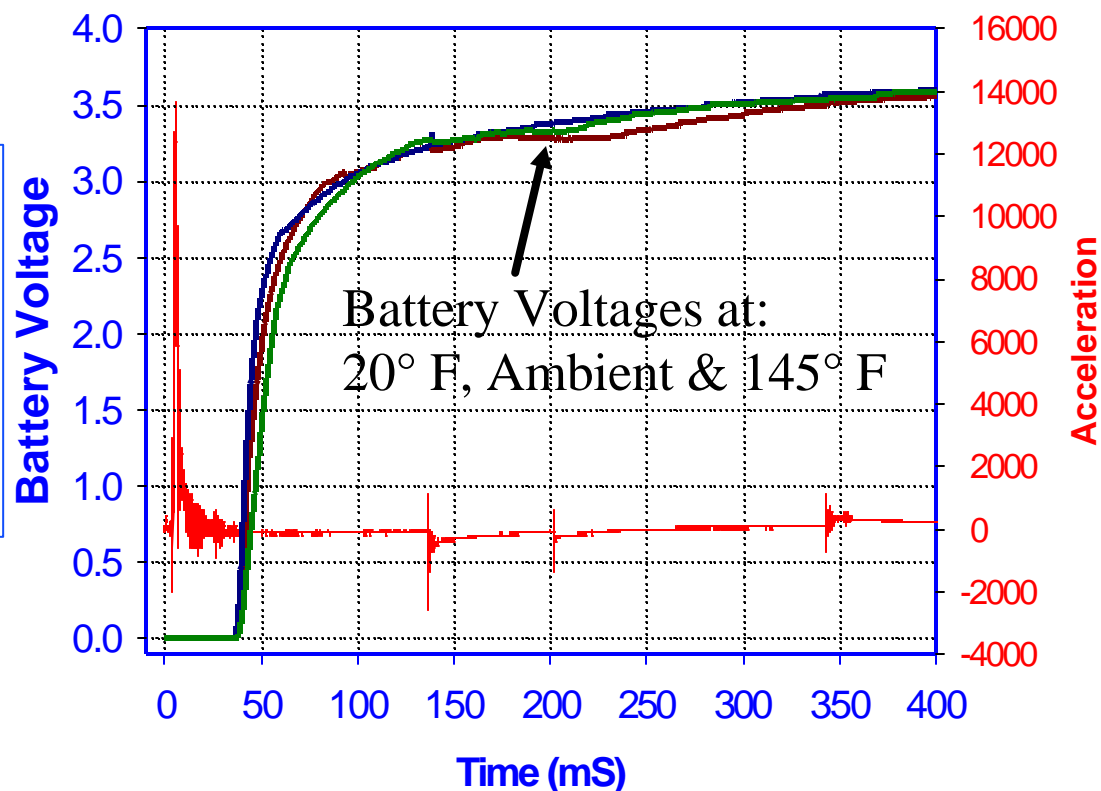
Battery Risetime

➤ Risetime Requirement:

- Prox Load 48 s
- Timer < 1 s

➤ Tested Risetime:

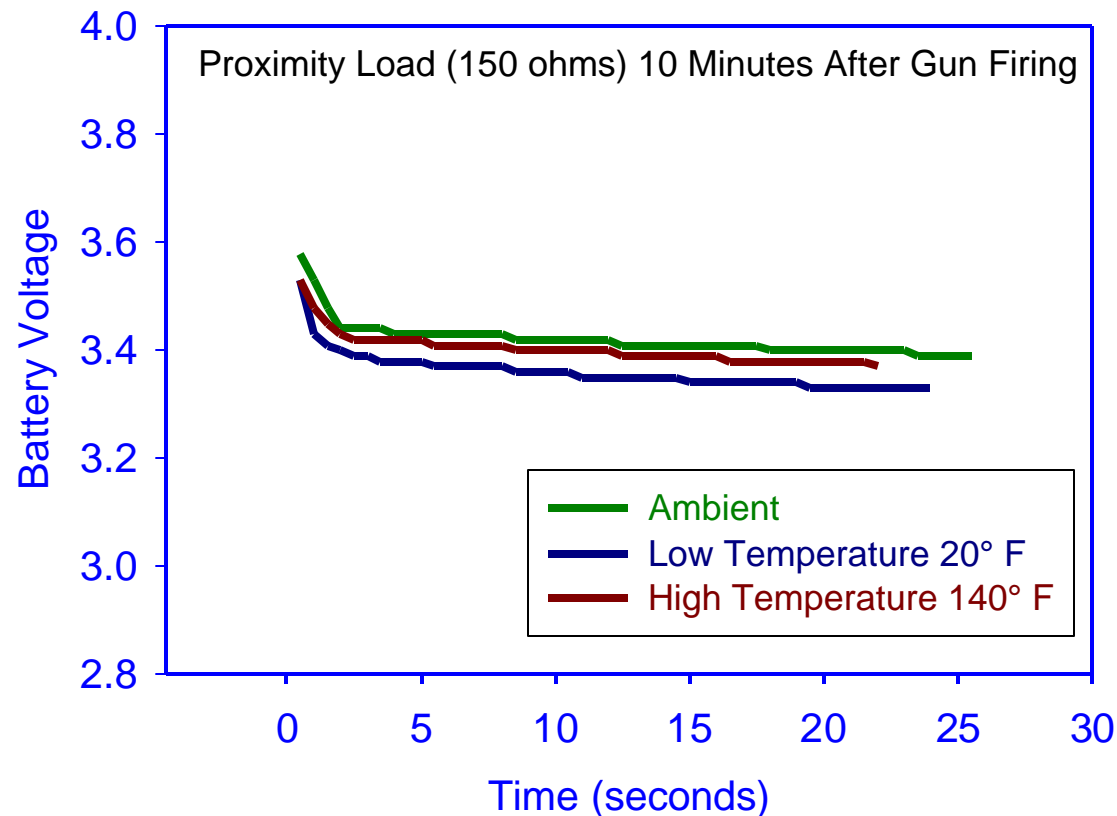
- Less Than 200 ms



Proximity Load

Prox. Load Requirement:

- 22 mA for 18 sec.
- Occurring between 48 sec. to 10 minutes after gun fire



Battery Drop Test Cushioning Study

- **Dynamic Requirements**
 - Survive 5-foot Drop Requirement onto Concrete in M80 Submunition
 - 100% activation at 8500 g's Gun Launch Setback
- **5-foot Drop Results**
 - 30% Activation Rate in POD Baseline Battery (no cushioning)
 - 0% Activation Rate Cushioned POD Baseline Battery
 - 6 cushion designs evaluated in 23 tests to eliminate high frequency drop shock
- **Gun Launch Activation Results**
 - 1 battery out of 23 tested failed to activate (Donut cushion configuration)
- **Evaluation provides confidence that both the 5-foot Drop and Gun Launch Activation Requirements can be satisfied with the Pad cushioning configuration**



POD BASELINE



.031" PAD, NO CAVITY PROJECTION



.031" DONUT W/ CAVITY PROJECTION

Summary

- A high power reserve battery has been successfully developed for the M80 PIP Proximity Fuze.
- Battery meets all the fuze electrical requirements
 - Processing / timing
 - High power proximity functions
 - Self-Destruct functions
- POD (Proof Of Design) batteries were successfully tested to non-operating requirements
- POD batteries were successfully tested to ERGM gun shock load profile